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I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PS 3191 for a patent by THORLOCK INTERNATIONAL LIMITED as filed on 25 June 2002.

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ORIGINAL

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Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: Low ESR Switch For Nuclear Resonance Measurements (#13)

The invention is described in the following statement:

"Low ESR Switch for Nuclear Resonance Measurements"

Field of the Invention

This invention relates to, but is not limited to, the detection of explosives and narcotics located within mail, airport luggage and other packages using nuclear quadrupole resonance (NQR), nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI) or similar nuclear resonance phenomena technique. More specifically the invention relates to switching between substantially different frequencies, whilst maintaining a low Equivalent Series Resistance (ESR) resistance across a resonant coil for the purposes of nuclear resonance detection.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Background Art

The following discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge in Australia as at the priority date of the application.

In the fields of Magnetic Resonance Imaging (MRI), Nuclear Magnetic Resonance (NMR), and Nuclear Quadrupole Resonance (NQR), resonant coils are used to detect signals from the substance or item under examination. The coils are connected to capacitors to resonate the system at an RF frequency. As can be seen from equation 1 below, by changing the capacitance and not changing the coil dimensions (i.e. upon which the inductance L is dependent) the frequency changes:

$$\omega^2 = \frac{1}{L.C} \quad \text{..............................(1)}$$

In the field of NQR, in particular, there is often the need to try and detect different substances at very different frequencies. For instance, an NQR explosive detector may be required to detect RDX at 5.2MHz and then be switched to PETN which has a resonant frequency at 0.89MHz. As is evident from equation 1, to move the resonant frequency of the coil from 5.2MHz to 0.89MHz requires a large number of capacitors to be switched into the circuit, a typical example of which is shown at Figure 1 of the drawings. As shown capacitors 7 and 8 are connected in parallel with a coil 9 to form a resonant circuit, whereby the capacitor 7 is switched in or out of the circuit by means of the switch 5. To perform this switching operation an operator skilled in the art could use a relay or semiconductor device.

The strength of signal derived from an NQR device is partially dependent upon the Q (quality factor) of the coil system. According to equation 2 the Q of a coil is dependent upon the resistance (R) of the circuit.

$$Q = \frac{\omega L}{R} \quad \text{..(2)}$$

Hence the ESR of the switching device will affect the circuit as it will be a part of it when switching between frequencies is required. The switch ideally needs to have zero ESR, however this is unrealistic. An inherent problem with mechanical relays is that they have a high ESR and are prone to 'catching' after many operations. Semiconductor devices while being more reliable than relays, also have a high ESR.

Disclosure of the Invention

It is an object of the present invention to lower the resistance of the coil-capacitor circuit of an NQR, NMR or MRI circuit to increase the Q of the system and thus increase sensitivity.

The present invention seeks to solve this problem by introducing a low ESR switch. The introduction of this switch lowers the resistance of the coil-capacitor circuit and results in a higher Q than would otherwise be achieved if relays or semiconductor devices were used.

In accordance with a first aspect of the present invention there is provided a low ESR switch which is added to the coil-capacitor circuit of an NQR, NMR or MRI device. This switch comprises parallel bars separated by a small distance and can be made to touch (and thus connect the circuit) by the action of actuating means such as a pneumatic air piston system, motor or solenoid. In such an arrangement the parallel bars may be guided into place by insulated guide rods.

Preferably, the parallel bars contacts are made from copper.

Preferably, the parallel bars contacts are made or coated with gold.

Preferably, the parallel bars contacts are made or coated with rhodium.

Preferably, the parallel bars contacts are made or coated with silver.

Preferably, the parallel bars contacts are made or coated with mercury and are contained within a vessel which prevents the escape of the mercury.

Preferably, the entire switch is contained within a vacuum vessel.

Preferably, the switch consists of an oval cross sectioned rod lying between two concave parallel bars. The oval cross section rod may be rotated to connect or disconnect with concave parallel bars.

Preferably, the switch comprises an elongated multipole switch, where the rotation of the switch allows lugs to touch and thus connect the circuit.

Brief Description of the Drawings

The invention will be better understood in the light of the following description of the best mode for carrying out the invention. The description is made with reference to Figures 2 to 4, and several specific embodiments of the best mode. The drawings accompanying the specification are described below:

Figure 1 shows the prior art arrangement for switching in extra capacitance into a resonant circuit.

Figure 2 shows the first embodiment of the low ESR switch.

Figure 3 shows the eighth embodiment of the present invention.

Figure 4 shows the fifteenth embodiment of the present invention.

Best Mode(s) for Carrying Out the Invention

The best mode for carrying out the invention involves adding a low ESR switch to a coil-capacitor circuit of an NMR, MRI or NQR system of the type shown in Figure 1. The low ESR switch consists of two parallel metal bars with a small gap between them. A device pushes the two metallic bars together to form contact. The parallel bars could be any shape which provides solid contact, for instance two flat bars or a triangular shaped bar impinging upon a concave triangular shape.

The first embodiment of the best mode is directed towards an ESR switch of the form shown in Fig.2. The switch comprises two flat parallel metallic bars 10, which are separated by a small distance. A pneumatic air piston system or a motor or solenoid (not shown in Fig.2) drive the two bars together when contact is required. Alignment is maintained through insulated guide rods 20. This action could occur under direction from a controlling computer.

The large contact surface area of the switch provides extra surface area for the current to flow over thus minimising the resistance. This switch allows the

operator to increase the capacitance of the circuit without detrimentally compromising the resistance and thus the Q of the coil-capacitor system.

For example in NQR, when switching from RDX to PETN frequencies, a large insertion of capacitance into the circuit is required, in the order of nanoFarads. The switch is closed by the computer, resulting in contact between the coil and the second bank of capacitors, resulting in the frequency being changed from near 5MHz to near 0.89MHz.

As well as performing coarse tuning like above, smaller versions of the switch can be used to fine tune the coil. These smaller versions replace relays and result in a lowering of the resistance of the final circuit and thus an increase in Q.

The second embodiment is the same as the first embodiment, except that parallel bars are coated with a metal which prevents corrosion and/or prevents carbonisation of the metal surface.

The third embodiment, is the same as the second where the metal added is gold. The addition of gold contacts prevents corrosion of the metal surface by oxidation and carbonisation. As the gold is soft and malleable the contacts mold together thus providing a better contact.

The fourth embodiment is the same as the second, except that the parallel bars are coated with rhodium. The addition of rhodium contacts prevents corrosion and carbonisation of the metal surface. Rhodium is also extremely hard and will not deform with time allowing quality contacts over the lifetime of the switch.

The fifth embodiment is the same as the second except that the parallel bars are coated with liquid mercury. The addition of mercury contacts prevents corrosions and carbonisation of the metal surface. The addition of mercury would require a containment vessel to prevent the loss of mercury into environment due to its hazardous health effects.

The sixth embodiment is the same as the second except that the parallel bars are coated with silver. The addition of silver prevents corrosion of the metal surface underneath.

The seventh embodiment is the same as the first, except that the entire switch is isolated inside a vacuum. The use of a vacuum chamber around the metal bars prevents the oxidation of these bars allowing an increase in the usuable lifetime of the switch.

The eighth embodiment involves adding a low ESR switch of the type shown in Figure 3 to the coil-capacitor circuit of an NQR, NMR or MRI system. The low ESR switch consists of a rotatable oval shaped cross section metallic bar 35 lying between two concave plates or bars 40. A pneumatic air piston system or a motor or solenoid turns the oval cross section shape bar to contact the plates 40 when contact is required. This action occurs under direction from a controlling computer. The large contact surface area of the switch provides extra surface area for the current to flow over thus minimising the resistance. This switch allows an increase in the capacitance of the circuit without detrimentally compromising the resistance and thus Q of the coil-capacitor system.

The ninth embodiment is the same as the eighth embodiment, except that the oval shaped cross section bars are coated with a metal to prevent corrosion and carbonisation of the metal surface.

The tenth embodiment is the same as the ninth embodiment, except that the oval shaped cross section bars are coated with gold.

The eleventh embodiment is the same as the ninth embodiment, except that the oval shaped cross section bars are coated with rhodium.

The twelfth embodiment is the same as the ninth embodiment, except that the oval shaped cross section bars are coated with silver.

The thirteenth embodiment is the same as the ninth embodiment, except that the oval shaped cross section bars are coated with liquid mercury. The liquid mercury is sealed within a vessel.

The fourteenth embodiment is the same as the ninth embodiment, except that the switch is sealed within a vacuum chamber to prevent corrosion of the switch.

The fifteenth embodiment involves adding a low ESR switch of the type shown in Figure 4 to the coil-capacitor circuit of a NQR, NMR or MRI system. The low ESR switch consists of a rotatable multipole switch with metallic lugs 45 providing a sliding connection with mounted concave contacts 55. A pneumatic air piston system or a motor or solenoid (not shown) turns the multipole switch when contact is required. This action may occur under direction from a controlling computer. The large contact surface area of the switch provides extra surface area for the current to flow over thus minimising the resistance. This switch allows an increase in the capacitance of the circuit without detrimentally compromising the resistance and thus Q of the coil-capacitor system. The capacitors 50 that are to be switched into the circuit are located within the barrel section of the switch. Each capacitor system is electrically isolated from each other such that when the switch is turned, only the capacitors connected to the lugs that make contact with the concave contacts conduct electricity.

The sixteenth embodiment is the same as the fifteenth embodiment, except that the metallic lugs of the multipole switch are coated with a metal to prevent corrosion and carbonisation of metal surface of the switch.

The seventeenth embodiment is the same as the sixteenth embodiment, except that the metallic lugs of the multipole switch are coated with gold.

The eighteenth embodiment is the same as the sixteenth embodiment, except that the metallic lugs of the multipole switch are coated with rhodium.

The nineteenth embodiment is the same as the sixteenth embodiment, except that the metallic lugs of the multipole switch are coated with silver.

The twentieth embodiment is the same as the sixteenth embodiment, except that the metallic lugs of the multipole switch are coated with mercury. The mercury is contained within a sealed vessel.

The twenty first embodiment is the same as the fifteenth embodiment, except that the multipole switch is isolated within a vacuum to prevent corrosion.

It should be appreciated that the scope of the present invention is not limited to the specific embodiments described herein and that changes and modifications in accordance with common knowledge in the art of the invention may be made that still fall within the scope of the invention.

Dated this 25th day of [illegible]

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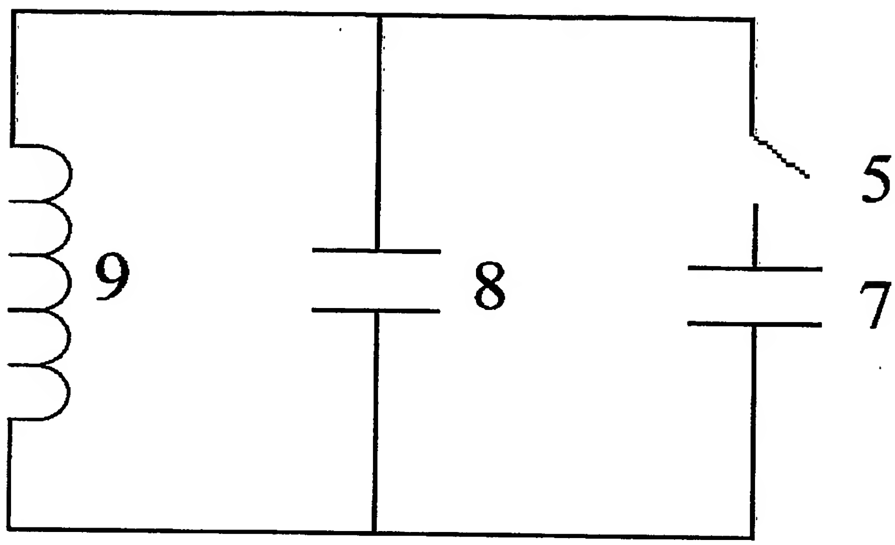

Fig 1

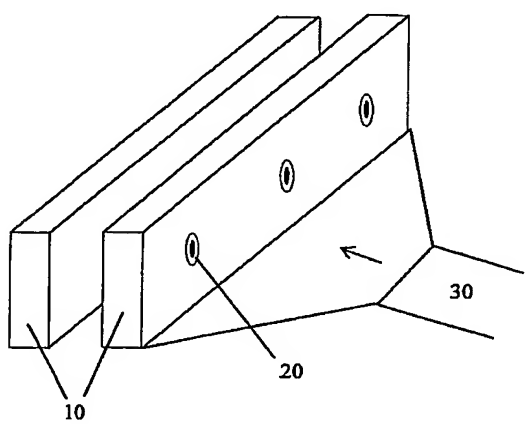

Fig 2

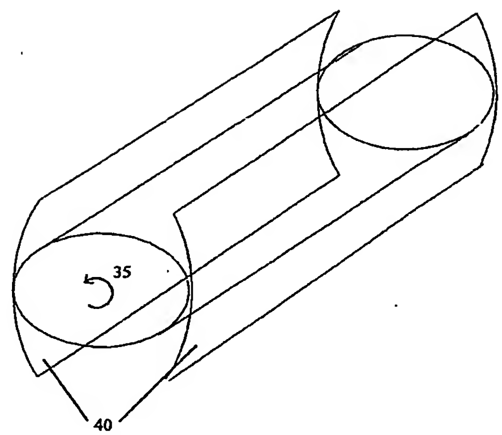

Fig 3

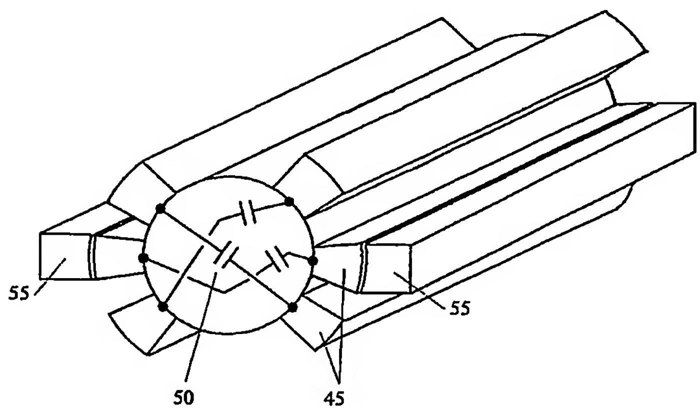

Fig 4